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ABSTRACT

The nature of science encompasses the entire world and within that realm, patterns of life can be observed, interpreted, and organized into a sensible arrangement of understanding. By discovering, through an intricate process, how shapes and images form into a complete design or sequence, students related similar scientific patterns to their own development and life cycle through a constructivist framework. They further predicted that all things were different but unified to form a whole. The focus of the study was to integrate into the curriculum a teaching unit of primates based on research conducted by an elementary school teacher. Fifth grade students, working together in collaborative learning groups in hands-on, minds-on activities, delineated symmetrical patterns in travel routes, eating habits, vocalizations, diet preferences, and social behavior of squirrel monkeys. Observations were evaluated in a combined effort to gain knowledge about primates and explore their role in the nature of science. (Contains 19 references.) (Author/YDS)

A Community of Learners: Linking Scientific Patterns of Life

ED 444 842

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This paper was presented at the annual meeting of the National Association for Research in Science Teaching on 31 March 1999 in Boston, MA.

Abstract

The nature of science encompasses our entire world and within that realm, we observe, interpret, and organize patterns of life into a sensible arrangement of understanding. By discovering, through an intricate process, how shapes and images form into a complete design or sequence, students related similar scientific patterns to their own development and life cycle through a constructivist framework. They further

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Introduction

In this investigation, I have undertaken research to explore how children can predict and observe the formation of sequential patterns. Through discovery and emphasis on science process skills, students created simple and complex patterns in order to seek solutions to problems and apply them to the nature of science. By integrating a teaching unit on primates and developing an atmosphere for students to become stakeholders in collaborative learning groups, they began to delineate symmetrical patterns in travel routes and vocalizations of squirrel monkeys. As a result, they perceived that many things in the universe are proportional and that science lends itself to uniform design.

The purpose of this study is to address the following questions:

- Do students visualize patterns as individual shapes or do they imagine the design as one entity?
- Can students learn the nature of science by visualizing patterns? i.e., cells and the life cycle of primates.
- Does a constructivist framework allow students to relate their view of patterns to the study of science?

Theoretical Framework

"Science is too important, too interesting and too much fun not to be communicated accurately, without misleading exaggeration and in a way that we all can understand" (Levy, 1998, p. 10). Lynch (1998) notes, "Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society" (p. 133). According to Webster's Dictionary (1956), patterns are "an arrangement or composition that suggests or reveals a design; a configuration" (p. 617). Mathematically, it is an arrangement or model that can be used to solve problems.

Children are cognizant of patterns in their environment. They observe them in the designs of clothes, in daily routines and simple chores, and even in the natural phenomena of nature, such as veins on leaves, color of animals and bodies of insects.

To enhance their learning, constructivism was employed as the method of teaching. It is a referent that builds a classroom and stresses student learning (Tobin & Tippins, 1993). "Typically, the teacher takes account of what students know, maximizes social interaction between learners such that they can negotiate meaning, and provides a variety of sensory experiences from which learning is built" (Tobin & Tippins, 1993, p. 7). By creating collaborative learning groups for students to optimize their experiences and interact and negotiate consensual agreement with their peers, students acquire new information, change their thought and construct new and different understandings. "The human species seems to have a cooperation imperative: We desire and seek out opportunities to operate jointly with others to achieve mutual goals" (Johnson & Johnson, 1991, p. 6). There are many systems that function in unity; the human body, family units, legal and economic environments. Educationally, a constructivist pedagogy provides ample opportunity for students to work together in science through hands-on activities, which become springboards for student discussion, vocabulary development, content reading, and writing. For purposes of this study, students shared knowledge, predicted and constructed new patterns, and accomplished the goal of creating a whole from many parts.

The Study

In this study, I developed curriculum to correlate patterns to the nature of science. Through hands-on, minds-on experiments, inquiry and science process skills were emphasized, enhancing students' ability to predict, observe and conclude.

Pedagogically, students were responsible for their own learning. Within a collaborative learning group, each was a jobholder and had to abide by the rules of the group to reach consensual agreement. Inside that framework, social discourse occurred which caused a larger learning group to form. Ultimately it prompted students to change their interpretation of the newfound knowledge, thus creating yet another joint construction. Roth (1993) concurs; "Constructivists recognize that, rather than being transferred from one individual to another, knowledge has

to" be constructed by each individual through his or her active engagement with the physical and/or social environment....discourse in collaborative situations goes beyond mere negotiation.... The processes of co-construction and individual construction of knowledge occur simultaneously as new more powerful structures may be constructed...."(p. 146).

In my classroom, 31 fifth graders were animated and actively engaged in learning about cells, patterns and primates. Collaborative learning groups were sometimes comprised of selected friends or made from permanent seating arrangements. In all situations, minimal directions were given to the whole class and each group devised their own decision-making process to define a member's specific job; i.e., manager, assistant manager, materials manager, recorder, reporter, member-at-large. Students were anxious to succeed and cooperated with each other. They were also motivated to solve a problem and it was rare to observe a non-participating student.

The School

David Fairchild Elementary School is located in an urban community, lower to middle class neighborhood with 585 students attending; 33% receive free or reduced-cost lunches; 55.1% are Hispanic, 29.1% White, Non-Hispanic, 14.1% are African American, and 1.8% are Asian American.

The fifth grade classroom is comprised of eight gifted students (three attend a nearby resource gifted center twice weekly), five attend the in-house gifted program daily for Language Arts instruction), two ESOL (English for Speakers of Other Languages) students, and one ESE (Exceptional Student Education) student. There are 19 females and 12 males; 20 Hispanic, eight White, and three African Americans. Fifteen students are Patrol Guards, and six are members of Future Teachers of America, assisting teachers in their classroom during the lunch period. Three students participate as officers in the David Fairchild Bank, a facility located on the school grounds. Incorporated in 1984 for Fairchild students, who manage it, the bank is sponsored by the First National Bank of South Miami, Florida. One student, president of the Student Council, is a member of the Educational Excellence School Advisory Council comprised of administrators, teachers, parents and students. The goal of the Council is to write and implement the School Improvement Plan, a plan that affects school-wide academic achievement.

Two fifth grade classrooms are attached and located in a portable unit at the far west end of the school, isolated from the main building. Desks are arranged in groups of four to six students in an area about 24 feet wide and 27 feet long.

State and County Curriculum Standards

The Competency-Based Curriculum (CBC) and the Florida Sunshine State Standards (SSS), mandated by the Miami-Dade County Public Schools and the State Education Department are required guidelines for development of curricula. Within these specifications, I developed curriculum in a combined effort to gain knowledge about cells, patterns, and primates, while exploring the nature of science.

Research Phases

Scientific Research on Primates

In collaboration with the DuMond Conservancy, Miami, Florida, research on primates was conducted in 15 acres of hammock and subtropical hardwood Amazonian rainforest in the park facilities located on the grounds of the Monkey Jungle. Founded in 1933, "the Monkey Jungle is a commercial zoological park devoted to primates. Its primary objective is the naturalistic display of primates in semi-free ranging environments and the establishment of these primates in social units...." (DuMond, 1968, p. 88-89). The unique display of primate habitat has resulted in a living museum and valuable laboratory in a threatened ecosystem. Residing in the rainforest are over 125 squirrel monkeys, three red howler monkeys, six capuchins and one troop of about 100 java crab-eating macaques. The DuMond Conservancy conducts and coordinates behavioral studies and provides educational programs.

During the fall and spring semesters, 1998, as part of my doctoral studies, I observed and charted the dietary needs, travel routes and social behavior of squirrel monkeys. I worked in conjunction with a primatologist, the Director of the DuMond Conservancy, and an intern from the National Institutes of Health (NIH). I learned about squirrel monkeys, their diet and their social interactions among members of the community (troop). Furthermore, I had the opportunity to observe other scientists from the United States care for the animals and conduct behavioral research. Collaborating with these scientists was crucial in giving me first-hand knowledge of primates.

As part of my duties, I gathered data for the *DuMond Conservancy Animal Study Protocol: Vocal Communication in Free-Ranging Squirrel Monkeys*, for Dr. J. D. Newman, NIH. Specifically we observed and charted the dietary habits of squirrel monkeys and listened to their vocalizations at the same time. "Most primates live in social groups in which they make use of a complex communication system"(Evans, 1997, p. 2). Even though their diet is supplemented with bananas and other fruits two times daily, squirrel monkeys constantly scan and forage for natural food in treetops, bushes and at ground level. They are selective in what and how they eat, using their fingers to peel and clean food. They bite slowly taking one bite at a time, chewing and swallowing carefully. I noticed that their sounds are squeaky clicks and since they are smaller primates, one hears them before they are actually within view, hiding in the confines of the jungle bushes and trees. Aggressive vocalizations occur when mothers protect their young or two males battle over food.

Traveling in small groups of four to six monkeys, squirrel monkeys move in well-defined routes, appearing to copy each other's behavior. However, their social group consists of a larger number of monkeys. Though one small group of either males, females or juveniles appears first, it is quickly followed by many more monkeys who are jumping, hopping or swinging.

It is not unusual to find each monkey member of the group dispersed over a large area, each engaging in very different activities such as foraging, scanning, or playing. They are constantly moving, with little time for rest. Even at rest, three to four curl up together as a unit with one standing guard, ears perked up. They are curious, alert and exceptionally aware of intruders or strange movements in their surroundings. The males, females and juveniles travel within their own groups, rarely mixing the sexes except for sexual contact. Mothers carry their babies on their

backs, protecting them from other monkeys and gathering food for them. They display aggressive behavior in play and also when threatened by another monkey in the troop. In my observation, it appeared to be centered on the gathering of food.

Scientists persistently speculate on the behavior of non-human primates. Dolhinow (1972) purports, "Many claims have been made as to which primates are most closely related to each other and to us; It is extremely important to understand the implications of these differing points of view in trying to answer questions about the evolution of primate behaviors" (p. 3). While observing the squirrel monkeys, I concluded that primates live in social groups to afford themselves protection from predators and the advantage of gathering food for survival. I noticed that scanning and foraging appear to be not only an activity for survival but also an activity to alleviate boredom. It provides them with nonstop exercise and an acute awareness of their surroundings.

Methods of Scientific Research

From the onset, I was fascinated with the study of primates and their relationship to the environment and man. The Monkey Jungle seemed to be a perfect setting for my interests, and I introduced myself to Dr. Sian Evans, primatologist and Director of the DuMond Conservancy. Together, we established a plan that would be beneficial to the Conservancy and my research. For about a year, on Saturdays and early evenings, my focus of study consisted of observing the dietary needs of squirrel monkeys in the rainforest. At the same time, I followed them, sometimes over precarious terrain, in order to chart their travel and feeding patterns and interrelationships with each other. I have recently decided to expand and focus my research on the java macaque females and their roles within a social group (troop). Dr. Evans has been an integral source of primate knowledge, and she also serves as an outstanding female role model in the field of science for both my students and myself.

Throughout the research, I have compiled a daily journal, including observations and comments from students and I have videotaped my students in the classroom and at the Monkey Jungle. Additionally, I have conducted a survey in an attempt to understand the students' views with regard to collaborative learning and have charted their progress in science content learning by graphing their grades every nine weeks.

Assessment of Scientific Research

The purpose of my classroom study was to assess students' knowledge and understanding of new concepts in science content, specifically the study of cells and primates and to apply observable patterns of nature to their comprehension of real world science.

Within the framework of constructivism, qualitative research was utilized, incorporating collaborative learning groups into the scheme of learning, thus focusing on prior experiences to cooperate with others and acquire new knowledge. Gipps (1996) remarks, "...the view of student learning built up during the 1970s and 1980s under the *é*constructivist label, which sees students as active constructors of their own world view and which insists that to be useful new information must be linked to the knowledge structures, or schemata, already held in long-term memory, suggests that learning will be different across individuals" (p. 5). Fourth generation evaluation, described by Guba and Lincoln (1989), is a developmental process for judging criteria and serves as one of the best methods for empowering students and encouraging them to be stakeholders in the learning process ".... and it forces stakeholders to confront and deal with the constructions of other groups" (p. 54-55).

In accordance with the previous year's research on action experiments conducted with third graders on bird migration (Greenspan, 1999), I continue to interpret data, approved by the Human Subjects in Research Committee at Florida State University, by consolidating fourth generation evaluation techniques. As part of the learning process, the Committee has given me permission to videotape students and allow them to view it at a future date.

Action Research in a Fifth Grade Classroom

This study reflects action research conducted in my fifth grade classroom. In an effort to relate patterns to the nature of science, I developed curriculum based on the study of patterns in cells and primates. By integrating scientific content and design sequence, the students were able to assimilate their knowledge of primates to patterns of nature even though, at times, it was difficult for them to perceive such a possibility. "How, then, does one recognize a primate pattern? How large or small a segment of behavior is a primate pattern?.... Each (author) agrees, however, that the aim of investigation into primate behavior is not description alone, that ultimately we all seek to understand the multiple factors that are responsible for each pattern and the relationship of patterns to each other" (Dolhinow, 1972, p. v).

Most lessons were organized in collaborative learning groups in a constructivist setting to optimize learning science content. Shapiro (1994) remarks, "Scientific information is presented to students through experiences that recognize students' interest in the ideas and understanding of others. By valuing the social construction of knowledge, we emphasize both the importance of working together to develop science knowledge and of comparing one's ideas with others in such experiences as group work and class discussions" (p. 6-7).

Learning about Cells

Initially, a unit on cells was investigated and experiments were conducted using microscopes. The guidelines of Miami-Dade Public Schools for fifth grade are implemented through the mastery of competencies. Learning about cells by examining them under the microscope is a science competency. By classifying

cells into plants and animals, students were able to differentiate the traits of each.

First, students learned to make dry and wet mounts by looking at plant cells, cork, elodea plants and onions. Next, they looked at animal cells

like cheek cells and the daphnia, a water flea. They studied the cell theory of Schleiden and Schwann, comparing and contrasting animal and plant cells, noting similarities and differences. At home, they created an animal cell dessert by cooling colored gelatin (cytoplasm) in Ziploc bags (cell membrane) and adding one jawbreaker (nucleus), jujube candy (ribosomes), gummy worms (mitochondria), sprinkles (lysosomes), shoestring licorice (endoplasmic reticulum), and jelly bean slices (vacuoles). Some created plant cells by adding split peas to represent chlorophyll and placing the cell in a cassette case (cell wall) (Vaszily, 1987). Students shared all the parts of the cell and explained the patterns that were created as the ingredients coagulated into a whole.

Finally, in collaborative groups they produced a three-dimensional model of a cell, sharing their finished products with classmates. Their prior knowledge about cells assisted them in observing and predicting differences between plant and animal cells, making inferences and discussing results. Each group enthusiastically explained the visual design of cells, becoming cognizant of the many patterns that occur in science and how nature perpetuates them.

Learning about Patterns

Students designed and created patterns from various mediums. First, forming partner-pair learning teams, students linked together six yellow cubes, six green cubes and six blue cubes. By predetermining the colors of the cubes, students were then able to detect a pattern of colors. Within a short period of time, they became animated and preferred to mix and match colors and create their own designs.

Second, étrainsi were created from one-inch graph paper. Still working with a partner, students developed étraini patterns, coloring each section to form a specific arrangement and cutting them in short and long étrains.i While displaying them on a clothesline and sharing with the entire class, students were delighted with their creations. Some were simple patterns with only two colors, one following the next, while others were more complex patterns displaying three and four colors, repeating itself.

Third, teams of students were given large sections of gray, dotted cloth. With minimal instructions, learning groups had to measure an isosceles triangle using a protractor to measure a 90-degree angle. Together, the group had to decide how many triangles they would need to create their pattern. By cutting and pasting the pieces of triangles (the amount of triangles was decided by each group), the design evolved into a whole unit. Students gave a title to their pattern. Some titles were éTriangle Spot,i éThe Evergreen Tree,i éThe Upside Tower,i éStars Rule,i éRight Side,i éRising Sun,i and éCompass.i While displaying them, each group had to justify their pattern. The following comments were made:

- If you fold it in half, it is the same.
- Ours is eight evergreen trees that make one big one.
- All our triangles go in the same direction and all touch.
- Ours is like a compass, N, S, E, W, but it is also NE, SE, SW, NW.
- Put ours upside down and it is an ice cream cone.

Students further made inferences from their triangular patterns, optimizing their critical thinking and science process skills. While comparing and contrasting they noted:

- éTriangle Spoti is spread out.
- éCompassi and éStars Rulei look like a shape.

One student noticed that each person in the group conveyed a distinct message about the pattern and asked, "Why do some people see things in a pattern and others see something else?" After much discussion, the consensus was that everyone had perceived things differently; i.e., each had developed his/her own imagination because of past experiences and family background. Students also remarked that parents could and do influence their behavior, concluding that all people are unique and special.

Fourth, in conjunction with the approaching holidays, an array of hands-on activities generated some original designs. By incorporating the history of Native American and Pilgrim attire into a Thanksgiving celebration, students made vests with intricate patterns. One student described it:

I'm an Indian and it [the vest] has a lot of patterns on it. The green leaves are on the top, one pointing left or right. Another is a circle and a space and so on. Above it, there is a pattern that is like triangles together pointing, one up and one down. Then it has a geometric shape beside the triangles. It has a peace sign and an ark and arrow. That is more or less how (what) my vest looks like.

Another student decided to be a Pilgrim:

My vest is supposed to be a Pilgrim. It is black with white sequins up and down the sides and sequins in a half circle going to the other side of the vest. Then between the half circle and the sequins going up and down the sides is green paint in a sort of zigzag line. That is what my Thanksgiving Pilgrim vest looks like.

Furthermore, collaborative learning groups of five to six students created candy patterns on gingerbread houses and produced wrapping paper for parent gifts. Although some groups found the task easy, others had difficulty formulating a repetitive design. One group created a pattern of candy canes as a walkway compiled with M&Ms as pebbles on the éstreet.i Another group used chocolate chips to make a pattern around a window frame. Those patterns were simplistic and fundamentally basic. However, another team created a complex sequence of rows of candy kisses and same colored M&Ms separated by red colored strands of licorice. This group criticized the other teams' houses because they were

convinced that their configuration was truly the archetype of all patterns.

Making wrapping paper proved to be an easy task. Students, individually, created mathematical patterns on newsletter paper, a thin ply, large-sized paper. Some contained recurring addition or subtraction problems, others were repeated shapes such as snowmen, Christmas trees or geometrical design. The most complex displayed mathematical equations and even/odd numbers. However, students were soon bored with the repetition chore and began to make larger designs within the pattern in order to complete the task.

Finally, pairs of students were given a Polaroid camera to take a photograph of any pattern observed on school grounds. When they returned to the classroom, they had to write a story emphasizing its significance and importance to the nature of science. One student described a rectangular fence as:

My pattern is negative, positive, negative, positive. The picture is significant. It is significant because people who use them don't even know that it is a pattern.

Another student commented about the portable classroom:

The pattern is the wall of the portable. The pattern is wood, space, wood, space, etc.

One noticed a tic-tac-toe gameboard display:

I took the picture because it is a neat pattern. I also took this picture because it is a fun game to play. The pattern is xoxoxoxox.

Yet another student finally related patterns to the nature of science:

The pattern is tree, no tree, tree, no tree. It has another pattern, too. This one is tree, grass, tree, grass. At first I didn't know that nature has a pattern, but now I do. Some people won't see a pattern, but I do.

Learning about Primates

To motivate the students and introduce the unit on primates, I presented a slide show depicting various species of primates residing in the Monkey Jungle. The slides were authentic because they not only presented primates living in a natural habitat but they showed how man assists these monkeys in their survival. DuMond (1968) states, "This facility offers a unique opportunity to observe the behavior of this primate (squirrel monkeys) in an environment that very closely approximates the field environment and yet offers certain advantages for control and experimentation. Yet basic questions regarding the normal social environment likely to be critical to the emotional development of these highly social animals, and those regarding the physical environment which provided the forces that shaped the evolution of each primate species, can only be answered through such field research" (p. 88).

Additionally, a large collage of primate photos and books from the library were displayed. Students read about the many different species of primates, learned to differentiate their characteristics and were fascinated to discover that primates travel and live in social groups.

During the course of study, a field trip was arranged by the DuMond Conservancy to attend the Monkey Jungle and students spent an entire day observing, listening and recording the sounds and sights of primates. "Anyone who has been around primates knows that they are quite vocal. Virtually all species produce a large repertoire of cackles, coos, screams, hoots, or pants that can be confounding for scientists who wish to figure out what these guys are saying" (Tagliatela, 1998, p. 2). At the Monkey Jungle, the primates roam free within the confines of a rainforest while visiting people stroll through fenced walkways. Primates drop aluminum bowls suspended on long chains from above and pull on them to prod tourists for peanuts and raisins. Many times, primates travel at ground level, sticking their slender fingers through the fence, begging for food. Hourly presentations teach visitors about the lowland gorilla, orangutan, red howler and java macaque. Presently, there are about 20 to 25 different species and about 350 primates residing at the Monkey Jungle, some are free ranging while others are permanently caged, such as the owl monkey and the lemur.

Upon return from the Monkey Jungle, students wrote stories with illustrations. Some students described their experience:

- I also can't wait to come again - this was truly an unforgettable trip - I loved it!
- Monkey Jungle was so cool! I saw so much that I never saw before...
- That is the story of our wonderful, fabulous "Monkey Jungle Journey," I hope to be back soon and hope our class will be able to adopt our own monkey.

Other students noted:

I learned that monkeys (è) undersides are called the ventral surface. Primates have two special things. They have hands that can grasp and grab and they have binocular vision that lets them judge distances. Prosimians and monkeys are New World monkeys. And last but not least I learned that babies (è) coats are called prenatal coats. I learned a lot and hope to learn more!

Monkeys are mammals. One type of monkey is Prosimian. Monkeys are very, very intelligent and are capable of learning many tricks. There are about 200 species of monkeys. Most of them live in tropical regions in Central and South America, Africa and Asia. Some species live in (the) forest...in trees. Others live in savannas...live on the ground.

We were also told that the young female javas are the smartest and will learn new behavior and imitate others (è) behavior. The leader has first choice of all the female javas and all the males are always trying to overthrow the leader.

In preparation for the next field trip, students worked collaboratively in teams to create a primate lunchbox, which they will eat during lunch the day of the field trip. Each group chose one species of primates, selected a diet, and designed a lunchbox with elaborate designs. It will contain all the foods that their primate eats daily.

Inviting an intern from the National Institutes of Health to visit the classroom was exciting and informative. Tagliatela (1997) notes that "the free ranging squirrel monkeys in the rainforest habitat of Monkey Jungle provide a suitable population for addressing questions related to the usage of affiliative vocalizations in other than captive conditions, their development and the role of individual recognition in conversations using these vocalizations" (p. 1). The researcher, in her study, examined the complex vocalizations of squirrel monkeys: gurren, purr, cackle, peep, chuck, twitter. In order for the students to understand that scientists first must classify research into categories, she placed several different objects on a table, such as a can of corn, pear, banana, apple, green light bulb, orange, carrot, and onion. Students began to classify these objects by fruit, vegetable, size, and color. In that regard, students listened to a tape recording of the short, abrupt vocalizations of some squirrel monkeys, classifying them into sounds of play, aggression, pleasure, mating and forewarning. Initially, it was difficult to discern the sounds of the monkeys and even more impossible to detect a pattern to the vocalization. However, after listening several times to the recording and dividing into collaborative learning groups to enact a vocalization, some of the students became proficient and were able to repeat the simple pitch and intonation. Eventually, a few groups were able to perceive a pattern.

Finally, I noticed that one of the most difficult tasks for students was relating patterns to primates. Initially, students noticed that there were patterns in the landscaping of the park and in the configuration of the cages. However, preliminary findings of patterns in primates' behavior proved to be beyond their ability of comprehension. Nonetheless, the more they observed the animals, the more they were able to see repetitive behavior in travel routes and in foraging and scanning for food. Goodall (1998) notes, "All of these careful observations, made in the natural habitat, helped to show that the societies and behavior of animals are far more complex than previously supposed by scientists" (p. 2185). Fortunately, my research is ongoing and with several more planned field trips, students will hopefully be able to delineate more symmetrical patterns in primate behavior.

Conclusions

Concluding the premise that science is devised of many patterns, students, in this study, learned to recognize and identify sequential designs in nature. The three questions addressed in the research were initially perceived as uncomplicated issues. However, as the study progressed, it became obvious that linking patterns to the nature of science was far more complicated and complex to distinguish than expected.

The first research question asked if students could visualize patterns as individual shapes within the pattern or as a single entity. The answer was twofold; learning about patterns proved to be both effortless in one respect and challenging in another.

For example, the study of cells facilitated the learning of more sophisticated and abstract patterns found in primate behavior. By observing the simple parts of a cell in a microscope, students learned to identify them and call them by name. Then they were ready to compare animal and plant cells. At this point, they were prepared to categorize the parts. At first, they only observed the nucleus as a sole marker of a cell but later they detected it as part of a pattern, which included ribosomes, lysosomes, and endoplasmic reticulum. Some, nonetheless, never recognized a design in the cells but those that did learned to view science differently. They realized that the real world contains patterns, units of interconnecting pieces, which also included the social behavior of primates.

Furthermore, their curiosity coupled with their prior experiences gave them the tools to link pieces to form a singular pattern such as pasting buttons on a vest or joining yellow cubes to blue ones. According to Shapiro (1994), "Learners are already making efforts to give meaning to the world long before coming to school. The nature and character of these efforts can be seen in patterns of thinking and behavior that give insight into how they organize their world" (p. 182).

In another activity, as students constructed one isosceles triangle, they realized they could assemble an additional design with several overlapping triangles, which was totally unique in its form. In other words, as they constructed more knowledge, building upon previous experiences, their thinking evolved from the concrete to the abstract. Inductively, they analyzed, synthesized, evaluated, and internalized science process skills. By approaching each problem through speculation, intuition, and guessing, they asked the right questions and made selected observations relevant to their questions.

As a final example, some of the students asked the following questions, after visiting the Monkey Jungle for the first time. They provide insight into some of the students' thinking:

- Can a primate be cloned?
- Do primates copy men or women at everything they do?
- Can apes be taught to do sign language?
- Can you teach a monkey anything?
- How smart are monkeys?

Other students, however, were not able to speculate or guess and asked simple questions:

- How much food can a squirrel monkey eat a day?
- How do they sleep?
- Is it possible that a monkey can catch a fish?

The second research question examines whether students can learn the nature of science by visualizing patterns. Observing repetitive design in daily life was simple compared to applying it to the nature of science. Intuitively, they were aware of patterns in clothes and daily experiences and had indeed formed some ideas relating to the issue of nature. However, it was not in the direction that I had envisioned. In their minds, the landscaping of trees, plants and flowers formed a pattern. I had hoped that they would see the more abstract patterns of science, such as the sound of an animal or the fronds of a plant. I visualized the details of the puzzle whereas they could only distinguish the larger pieces. Consequently, I had to modify my teaching by providing more opportunities to manipulate and explore. Bruffee (1995) agrees, "Teachers do not tell students what the right answer is in consensus-group collaborative learning, because the assumption is that no answer may be absolutely right" (p. 47).

Eventually, some students began to hear distinct patterns in primate vocalizations while others observed it in their movements. Since most of the monkeys travel quickly, the distinction was difficult to recognize. However, during this period of observation, basic skills (i.e., observing, communicating, classifying, measuring, inferring and predicting) were exhibited within the student groups and integrated skills (i.e., identifying variables, constructing tables and graphs, analyzing investigation, constructing hypotheses) were enhanced. As the students walked through the Monkey Jungle surrounded by primates, they saw the smallest detail; a hand movement, a squeak sound, a facial expression. After all, "scientific knowledge results from scientists' interpretive translation of their research data and direct conversation about it" (Bruffee, 1995, p. 52). By conducting research in collaborative groups and gathering data, students actively engaged in discourse toward a common goal of identifying primate patterns. Many were able to observe these patterns easily while others continued to recognize only the individual sounds and movements.

The third research question asks whether learning within the framework of constructivism allows students to relate their views of patterns to the study of science. Although students were given opportunities to discuss patterns in partner-pairs, it was obvious that they needed more support from other peers. Without realizing it, these student-pairs instinctively initiated discourse with students seated nearby. As fifth graders, they appeared to be more enthusiastic about learning science when they were allowed to interact socially with a small group of friends, animatedly expressing their views.

By incorporating a constructivist approach through collaborative learning groups, a community of responsive learners began to emerge. Students became stakeholders within a small-group setting, accepting the responsibility of solving a problem through social discourse. When one member of the group would appear off-task, others would cajole that person to refocus. Without even realizing the dimensions of their learning, students were totally absorbed in learning science content because they had ample opportunity to engage together. They became motivated, inspired, and self-confident risk-takers in the learning process, interested only in accomplishing the task. They were proud of their achievements and more than willing to share their information. Surprisingly, the decisions of smaller collaborative groups influenced the final resolve of the larger class group. Many times, the students had to alter and transform their construction of knowledge. In a survey relating their feelings toward learning science, the majority stated that they preferred to learn in groups:

I like to learn science when we can investigate and know what is the opinion of the other people.

The minority of students remarked:

I like to learn science by my teacher teaching us.

I like to learn science by making it into a game.

Finally, it must be noted that these fifth grade students are continually observing and attempting to connect a pattern to any area of science. One student in summarizing her knowledge of plants recently remarked:

Did you know that the way a plant grows is its pattern? When it grows it grows into a pattern. If leaves grow on a trunk of a tree, the little leaves make a pattern as it grows.

Developing a community of learners who can link scientific patterns of life requires many more life experiences and a maturity of spirit. The students have taken a few steps on that road but they have yet to make the giant leap toward understanding that the nature of science is basically a set of interconnected pieces that form a whole. While trying to make sense of the scientific world, one student declared:

Yesterday when Barbara (pseudonym) came I learned that primates have different sounds like chirps, chucks and more. She studies the sounds they make. She says it is very hard to distinguish each sound and what monkey is making the sound. She says she also categorizes them.

Yet another student stated:

I like learning about primates and patterns because if I see like a pattern I know that it is a pattern.

"However, understanding science requires knowing what scientists do, what they believe, and what personal traits they possess. Scientists...believe that knowledge is tentative; they are by nature, very curious. The procedures of investigation are the activities by which knowledge of natural phenomena is gained"(MDCPS, 1998). In this inquiry, a community of learners began its search to link patterns to the nature of science. Through discovery and exploration, they exchanged ideas, collaborated, communicated, and altered their conceptions to understand that sequential patterns are observable in nature. "The study of nonhuman primate vocalizations can provide insight into how other species think, and what they think about. By determining what sort of information other nonhuman primate species are vocalizing about and how they go about communicating this information, scientists can speculate about the evolutionary roots of human language" (Tagliatela, 1998, p.

<http://www.naral.org/naral/99conference/greenspan/greenspan.html>

2).

One fifth grader thanked the DuMond Conservancy for the opportunity to visit:

Thank you for letting us go to the Monkey Jungle for free. We really enjoyed it. We sure learned a lot more about monkeys that day! Anyway, thank you for taking us on a journey that taught us more about the animals in our environment. We also hope that in the future, other schools will be lucky enough to get this great opportunity to learn more about wildlife, not only in a jungle, but in a park! Thank you very much!

One of your monkey friends....

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